A Possible Safety Wall Between the Booster and the Main Ring

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Design Objective. A wall with a mechanical plug that will allow operation of the booster at full power (1.5×10^{13} p sec^{-1}) while permitting unrestricted occupancy of the main ring area on the other side (~ 2.9 n cm^{-2}sec^{-1}).

Location. Somewhere in the beam transport enclosure which connects the booster to the main ring.

Proposed Schemes.

1) A wall with a small hole (~ 3-inch diameter) preceded by a thick steel plug (~ 10 feet). This plug would a) attenuate and b) disperse the incident proton beam.

Objections: a) the plug will become very radioactive and it will require its own housing; b) during "beam stopping" the plug will become a "hot" neutron source and it will require its own shield. The only advantage of this method is that it uses a small amount of steel, assuming this is an advantage.

2) A single wall with its own built-in plug. One possible structure of the wall is given in Figure 1. This figure shows two iron profiles. The rectangular is easier to build. The tapered one uses less steel. A movable plug is shown with the tapered profile. Minimum steel thickness = 15 feet $\pm$ 6 inches. Minimum ordinary concrete thickness = 7 feet $\pm$ 3 inches.

Note: Actual measurements may show the need for either a plug of ordinary concrete or polyethylene on the downstream end of the shield or an external shield close to and along the beam pipe. The appendix shows the arguments which led to the wall dimensions.
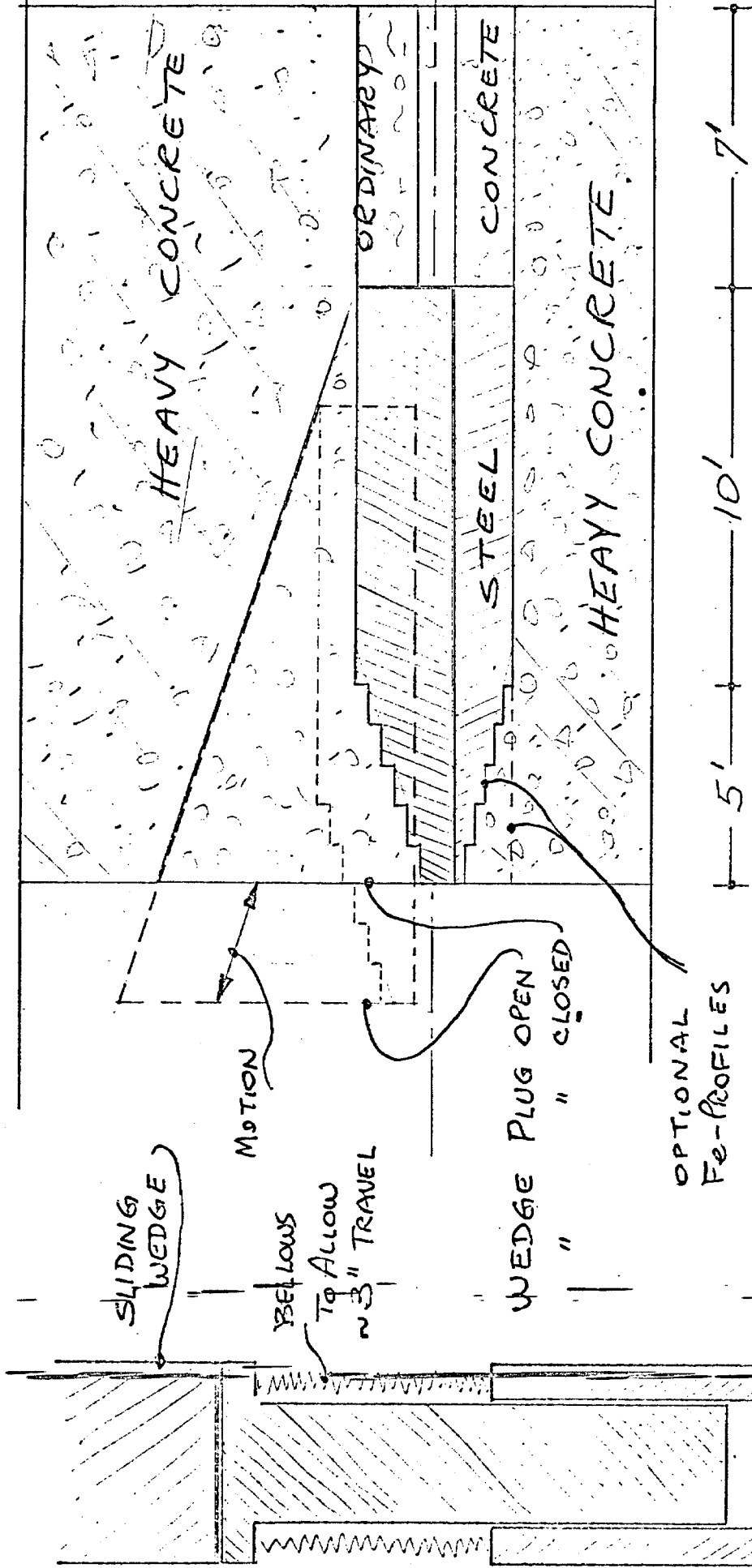
HEAVY CONCRETE

ORDINARY

CONCRETE

STEEL

HEAVY CONCRETE

SLIDING WEDGE

MOTION

BELLOWS TO ALLOW ~3" TRAVEL

WEDGE PLUG OPEN
" " CLOSED

OPTIONAL Fe-PROFILES

5'   10'   7'

Fig 1b. A Possible Cross Section For A Radiation Safety Wall Between The Booster & The Main Ring.

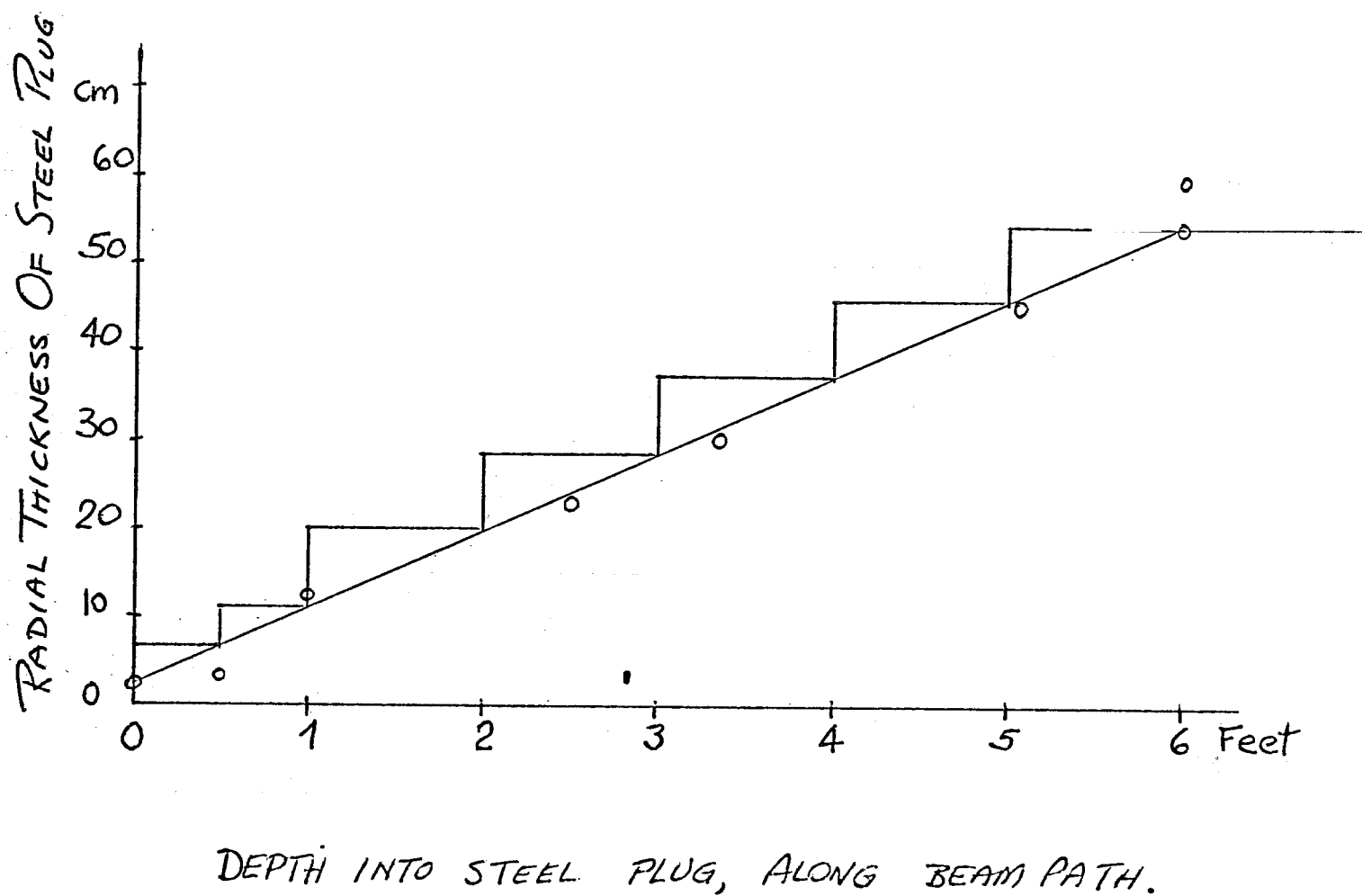Fig 1a. Study For A Possible Vacuum Seal For Br. Beam Plug.

DEPTH INTO STEEL PLUG, ALONG BEAM PATH.

Fig. 2

PROFILE OF A MINIMUM STEEL PLUG TO
ATTENUATE ABOUT 95% OF THE HADRONS PRODUCED
BY 10 GeV PROTONS ON STEEL.

APPENDIX

Derivation of the Safety Wall Dimensions

a) Length.

The length of a pure steel backstop for 1×10^{13} p sec^{-1} at 20 GeV/c is

given by Ranft[1]. This number is very close to our needs: 1.5×10^{13} p sec^{-1}

at 11 GeV/c. Hence, we will use it without changes. A pure steel backstop

would/allow a large flux of sub-1/2 MeV neutrons to stream out. Therefore,

4 to 5 mean free paths of ordinary concrete (6.5% water) is recommended.

	Ordinary Concrete	Steel
λ (g/cm^2)	95	120
ρ (g/cm^3)	2.3	7.8

5 λ (ord. concr.) 　　 = 　　 475 g/cm^2 　 = 　 207 cm 　 = 　 6.8 ft.

5 λ (steel) 　　 = 　　 600 g/cm^2

Ranft's steel 　　 = 　　 4000 g/cm^2

Our need 　　 = 　　 3400 g/cm^2 　 = 　 436 cm 　 = 　 14.3 ft.

We adopt: 　　 Steel = 15 ft ± 1/2 ft.

　　　　　 Ordinary Concrete = 7 ft ± 1/4 ft.

b) Lateral Steel Dimensions.

The lateral steel thickness would be such that 95% of the hadron flux will be

attenuated by the steel.

At large depths in the steel, the radial dependence of the hadron flux is

given by [1]

$$F(r) = k \; r^{-1} \exp(-r \; 7.8/133) \tag{1}$$

$$\bar{\phi}(R) = k \int_0^R 2\pi r\, dr\, F(r) = k\, 2\pi \int_0^R \exp(-4/17)$$

$$= k\, 34\pi \left[1 - \exp(-R/17)\right]$$

for $\dfrac{\bar{\phi}(R)}{\bar{\phi}(\infty)} = .95$, $R = 3 \times 17 = 54$ cm $= 1.77$ ft.

Formula (1) is a good representation for the radial dependence of the flux at depths (in the beam direction) of 1440 g/cm^2 (= 185 cm = 6 ft) and greater. At lesser depths the fall-out is faster and some savings in steel may be possible at extra cost in fitting steel. This profile is shown in Figure 2.